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Photodegradation of acetophenone and toluene in water by nano-TiO_2 powder supported on NaX zeolite

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ABSTRACT

TiO_2 was supported on a porous material, like NaX zeolite, by using sol–gel method and $TiCl_4$ as precursor. SEM of synthesized samples shows that nano titanium species are located on the external surface of the zeolite. Nano titanium species bound to the framework through Ti–O–Si bonds were also observed by IR analysis. The XRD patterns show that the supported TiO_2 are crystallized in anatase form, and the intensity of the X-ray diffraction peaks increased with increasing TiO_2 loading. These materials are used as photocatalyst for the degradation of acetophenone and toluene to H_2O and CO_2. The effect of some factors such as the pH of the photodegradation reaction, time of UV irradiation and amounts of TiO_2 loading and catalyst used was investigated. The results of this work show that as photocatalyst for the degradation of acetophenone and toluene, the nano titanium oxide based on NaX zeolite is superior over the nano titanium oxide powder alone.

1. Introduction

Nowadays the natural water resources are exposed to danger by a variety of hazardous chemical substances derived from man-made products. The injurious effects of chemicals on the earth's ecosystems are a cause for serious concern [1–6].

Effective treatments of toxicity pollutants have been required as part of water applications. During the past two decades, photocatalytic oxidation of organic contaminants has become attractive as a promising chemical procedure for water purification with titanium dioxide (TiO_2) [3–8]. TiO_2 has been the most investigated as the photocatalyst. The band gap of this "semiconductor" material is ca. 3.2 eV, which corresponds to radiation of wavelength around 380 nm [9]. Therefore, UV light with wavelength shorter than 380 nm is needed to excite the electrons of valence band to conduction band. The electron–hole pairs thus generated serve as the oxidizing and reducing agents. In photodegradation of pollutants in water, •OH radicals formed either through the interaction of water molecules with the holes or through the interaction of O_2 with the host electrons, are the key active species [10,11].

TiO_2 photocatalysis is effective for the decomposition of various organic contaminants in water. The efficiency of TiO_2 was reported to be influenced by many factors, such as crystalline structure [12–14], particle size [13,15–17], and preparation methods [18,19]. However, its practical application in aqueous media is limited, because of the difficulty of filtration and recovery of very small TiO_2 particles. In addition, TiO_2 has a polar surface and is not a good adsorbent by itself for nonpolar organic molecules, so addition of support materials may enhance its catalytic activity. Therefore, recent researches have been directed toward immobilizing TiO_2 powders onto a suitable supporting matrix [20,21]. These efforts have also increased the TiO_2 surface area by dispersing nanoparticles of TiO_2 on large surface area materials. To the best of our knowledge, the support materials have been used are silica gels, active carbon, zeolites and clays [15,22–28].

In the present study, nano size TiO_2 particles were supported on a micro porous material, namely NaX zeolite. The objective of this study was to examine the effect of zeolite microstructures on properties of the supported TiO_2 for the degradation of acetophenone and toluene in water.

2. Experimental

2.1. Materials

The reactants used in this study were titanium tetrachloride solution ($TiCl_4$) as a titania source, sodium hydroxide (NaOH), nitric acid (HNO_3), toluene and acetophenone. All the chemicals were analytical grade and were purchased from Merck. Also NaX zeolite was obtained from SPAG Corporation, Iran.

2.2. Preparation of titanium oxide

Stable sols of TiO_2 nano-particles were synthesized following the method of acid hydrolysis of $TiCl_4$ as precursor. In this method, nano sized TiO_2 was synthesized by adding NaOH to titanium tetrachloride solution until the pH of solution was adjusted to 7 at room temperature. After washing the resulting white precipitate with deionized water until complete removal of chloride ions, the pH of the slurry

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